Please add the following new claim.

26. (New) A metal interconnection according to claim 5, wherein, the metal material is comprised of at least one material selected from the group consisting of Zr, Cd, Ag, and Pb.

REMARKS

The Office Action dated December 21, 2001 has been received and carefully noted. The above amendments to the claims, and the following remarks, are submitted as a full and complete response thereto. By this Amendment, claims 1, 2, 5-7, 14-15, 17 and 22 are amended. Claim 26 is added. No new matter is added. Consideration of claims 1-26 is respectfully requested.

The Office Action rejected claims 1, 6, 13-15, 17, 20 and 22 under 35 U.S.C. §102(e) as being anticipated by Dubin (U.S. Patent No. 6,249,055). The Office Action states that Dubin discloses all the claimed elements of the present invention. Specifically, the Office Action states that Dubin discloses a metal interconnection buried in a dielectric layer having a barrier layer of tantalum nitride, an interconnect layer using copper, and an aluminum seed layer which can act as a adhesion layer to contain zirconium. Applicant respectfully submits that the present invention recites subject mater that is neither taught nor suggested by Dubin.

Claim 1 is directed to a metal interconnection buried in an insulation film. The invention comprises an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material. The invention also comprises an adhesion layer that contains zirconium formed between the barrier layer and the interconnection material. The adhesion layer is for improving an adhesion between the barrier layer and the interconnection material.

Claim 6 is directed to a semiconductor device that comprises a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, and an insulation film formed on the base substrate. The insulation film has an opening. The device further comprises a metal interconnection

formed buried in the opening which includes an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the barrier layer and the interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

The present invention provides numerous unobvious advantages over the prior art. For instance, the present invention provides better adhesive for the interconnective material so that the copper resistivity is decreased as well as improving the electro-migration resistance. Therefore, the features of the present invention as claimed, provides a more efficient semiconductor device. Thus, it is respectfully submitted that the prior art fails to disclose or suggest the features of the Applicant's invention, and therefore fails to provide the advantages which are provided by the present invention.

The metal interconnection according to the present invention has a feature that is neither taught nor suggested by Dubin. In particular, the adhesion layer for improving adhesion between the barrier layer and the interconnection material is formed between the barrier layer and the interconnection material. Thus, the adhesion layer is formed directly on the barrier layer. Also, the present invention provides a Zirconium (Zr) containing layer which has good adhesion to both the barrier layer and the Copper (Cu) containing layer.

In contrast, Dubin discloses a seed layer which enhances nucleation and adhesion between the electroplated Cu layer and the Al alloy or Mg alloy layer. The seed layer of Dubin, however, is not for enhancing adhesion between the barrier layer and the electroplated Cu layer. The seed layer 56 is formed directly on the Al alloy or Mg alloy layer 53 rather than the barrier layer 52. Thus, the seed layer of Dubin is not for improving adhesion between the barrier layer and the Cu containing layer. Accordingly, Dubin neither teaches nor suggests that the Zr containing layer is used for improving adhesion between the barrier layer and the Cu containing layer. Therefore, Applicant respectfully submits that Dubin does not anticipate the claimed invention. Accordingly, Applicant respectfully requests the withdrawal of the rejection of claims 1, 6, 13-15, 17, 20, and 22.

Claims 2, 7 and 19 are rejected under 35 U.S.C. §103(a) as being unpatentable over Dubin in view of Kim et al (U.S. Patent No. 4,7512,349). The Office Action states that the combination of Dubin and Kim disclose all the claimed features. Applicant respectfully

submits that the combination of Dubin and Kim neither teach nor suggest all the claimed features of the present invention.

Claim 2 is directed to a metal interconnection buried in an insulation film. The metal interconnection comprises an interconnection material containing copper as a main component. A barrier layer is formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the insulation film and the interconnection material. An adhesion layer containing zirconium formed between the insulation film and the barrier layer is also disclosed. The adhesion layer is for improving the adhesion between the insulation film and the barrier layer.

Claim 7 is directed to a semiconductor device. The device comprises a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate. An insulation film formed on the base substrate and having a opening. A metal interconnection formed buried in the opening. The metal interconnection includes an interconnection material containing copper as a main component. A barrier layer formed between the insulation film and the interconnection material. An adhesion layer containing zirconium formed between the insulation film and the barrier layer. The adhesion layer is for improving an adhesion between the insulation film and the barrier layer.

Claim 19, depends upon claim 17 and is directed to a method for fabricating a semiconductor device. The method comprises before the step of forming islands, the step of forming the second adhesion layer containing zirconium on the barrier layer.

Applicants submit that claims 2, 7, and 19 recite subject matter that is neither disclosed nor suggested by the combination of Dubin and Kim. In particular, the adhesion layer for improving adhesion between the insulation film and the barrier layer is formed between the insulation film and the barrier layer is neither taught or suggested by the applied art. Also, neither Kim nor Dubin teach or suggest that the Zr containing layer is used as an adhesion layer between the barrier layer and the insulation film.

Additionally, it should be noted that Kim is not utilized in buried metal interconnection technology as claimed in the present invention. For instance, Kim discloses a Zirconium (Zr) layer that is used as an adhesion layer between the ceramic layer or the polyamide layer and the copper layer. Whereas, the present invention

comprises an adhesion layer containing zirconium that is formed between the insulation film and the barrier layer. Furthermore, Kim neither teaches nor suggests that the Zr containing layer is used as an adhesion layer between the barrier layer and the insulation film. Also, Dubin neither teaches nor suggests that the Zr containing layer is used as a adhesion layer between the barrier layer and the insulation film. Thus, Kim clearly does not cure the deficiencies of Dubin. Therefore, Applicant respectfully requests for the withdrawal of the rejection of claims 2, 7, an 19.

Claims 3, 4, 8-12, 16, 18, 21, and 23-25 are rejected under 35 U.S.C. §103(a) as being unpatentable over Dubin in view of Kim et al. and further in view of Venkatraman (U.S. Patent No. 5,677,244). The Office Action states the combination of Dubin and Kim teach all the elements presented in the rejected claims except for a copper interconnection structure where islands are grown. The Office Action utilizes Venkatraman to teach this claimed feature. Applicants respectfully submit that the combination of the applied art neither teaches nor suggests all the claimed features of the present invention.

Venkatraman is directed to an interconnect structure that is formed by filling a dual damascene structure with a conductive material. In particular, Venkatraman discloses doping the interconnect structure with copper. Venkatraman also discloses a discontinuous film made up of islands of conductive material and that the portions of the underlying barrier layer are also exposed to improve the adhesion of the material used to fill the interconnect structure. However, Venkatraman does not cure the deficiencies of Dubin and Kim. For instance, the discontinuous copper (Cu) film (islands) is not for improving the adhesion between the barrier layer 13 and the A1 conductive layer 14, but for doping copper (Cu) into the A1 conductive layer 14. When the continuous copper (Cu) film is formed between the barrier layer 13 and the A1 conductive layer 14, the adhesion between the barrier layer 13 and the A1 conductive layer 14 is degraded, so that, in Venkatraman, the Cu film is discontinuously formed on the barrier layer 13. When the discontinuous Cu film is not formed between the barrier layer 13 and the A1 conductive layer 14, the adhesion is further improved.

In the present invention, islands of Cu-Zr alloy is for further improving adhesion between the adhesion layer and the barrier layer, so that islands of Cu-Zr alloy of the present invention is clearly different from the discontinuous Cu film of Venkatraman.

Venkatraman neither teaches nor suggests islands of Cu-Zr alloy. Thus, Venkatraman does not cure the deficiencies of Dubin and Kim. Therefore, the combination of Venkatraman, Dubin and Kim do not teach or suggest all the claimed features of the present invention. Also, it should be noted that claims 3, 4, 8-12, 16, 21, and 23-25 are either directly or indirectly dependent upon patentable subject matter, therefore they are likewise patentable. Accordingly, Applicant respectfully requests the withdrawal of the rejection of claims 3, 4, 8-12, 16, 21, and 23-25.

Claim 5 is rejected under 35 U.S.C. §103(a) as being unpatentable over Dubin in view of Farrar (U.S. Patent No. 6,284,656). The Office Action states Dubin discloses all the elements recited in claim 5 except the solubility or the resistivity of the material used. However, the Office Action utilizes Farrar to suggest that Zr is used to lower the solubility without increasing the resistance to much. Applicant respectfully submits that the combination of Dubin and Farrar neither teaches nor suggests all the elements recited in claim 5.

Claim 5 is directed to a metal interconnection buried in an insulation film. The metal interconnection comprises an interconnection material containing copper as a main component. A barrier layer is formed between the insulation film and the interconnection material. An adhesion layer containing a metal material having a solid solubility limit of not more than 20% wt% in copper and a resistivity increase of not more that 19.8 % when solved in copper. The adhesion layer is for improving an adhesion between the barrier layer and the interconnection material.

Farrar is directed to a method of fabricating integrated circuits interconnects using copper and polymer based insulation. Farrar also discloses that zirconius, hafnium, titanium may be used as suitable adhesion layer materials and suggesting that titanium has a lower solubility than copper. Furthermore, Farrar suggests inhibiting diffusion of zirconium into the copper and preventing the significant increase in resistance of the copper when a thin layer of CuZr is used in a specific temperature range.

It is respectfully submitted that Farrar does not cure the deficiencies of Dubin to teach all the elements of rejected claim 5. In particular, neither Dubin nor Farrar teach or suggest the claimed feature of an adhesion layer for improving adhesion between the barrier layer and the interconnection material. Also, Farrar does not disclose having

an adhesion layer containing a metal layer having a solid solubility limit of not more that 20% by weight in copper and a resistivity increase of not more than 19.8% when dissolved in copper. Therefore, it is submitted that neither Farrar nor Dubin disclose all the elements of the claimed invention. Accordingly, Applicant respectfully requests the withdrawal of the rejection of claim 5.

In view of the distinctions discussed above, withdrawal of the rejections to claims 1-25 is respectfully requested. Specifically, claims 1, 2, 5, 6, 7, 14, 15, 17, and 22 have been amended. Claim 26 has been added and no new matter has been presented. Rejection of claims 1-25 has been properly traversed in view of the remarks mentioned above. Therefore, Applicant submits that the application is now in condition for allowance with claims 1-26 contained therein.

Should the Examiner believe the application is not in condition for allowance, the Examiner is invited to contact Applicant's undersigned attorney at the telephone number listed below.

In the event this paper is not considered to be timely filed, Applicant respectfully petitions for an appropriate extension of time. The Commissioner is authorized to charge payment for any additional fees which may be required with respect to this paper to Counsel's Deposit Account 01-2300.

Respectfully submitted,

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Enclosures: Marked-Up Copy of Amended Claims

MARKED-UP COPY OF CLAIMS

1. (Amended) A metal interconnection buried in an insulation film comprising:

[a barrier layer formed on the insulation film;

an adhesion layer containing zirconium formed on the barrier layer; and]

an interconnection material containing copper as a main component [formed on the barrier layer] ;

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

2. (Amended) A metal interconnection buried in an insulation film comprising:

[an adhesion layer containing zirconium formed on the insulation film;

a barrier layer formed on the adhesion layer; and]

an interconnection material containing copper as a main component [formed on the barrier layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the insulation film and the barrier layer, the adhesion layer being for improving an adhesion between the insulation film and the barrier layer.

5. (Amended) A metal interconnection buried in an insulation film comprising:

[a barrier layer formed on the insulation film;

an adhesion layer containing a metal material having a solid solubility limit of not more than 20 wt% in copper and a resistivity increase of not more than 19.8 % when solved in copper formed on the barrier layer; and]

an interconnection material containing copper as a main component [formed on the

adhesion layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing a metal material having a solid solubility limit of not more than 20 wt% in copper and a resistivity increase of not more than 19.8% when solved in copper, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

6. (Amended) A semiconductor device comprising:

a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

an insulation film formed on the base substrate, the insulation film having an opening; and

a metal interconnection formed buried in the opening including:

[a barrier layer formed on an inside wall and a bottom of the opening;

an adhesion layer containing zirconium formed on the barrier layer; and]

a metal interconnection material containing copper as a main component [formed on the adhesion layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

7. (Amended) A semiconductor device comprising:

a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

an insulation film formed on the base substrate, the insulation film having an opening; and

a metal interconnection formed buried in the opening including:

[an adhesion layer containing zirconium formed on an inside wall and a bottom of the opening;

a barrier layer formed on the adhesion layer; and]

a metal interconnection material containing copper as a main component [formed on the barrier layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the insulation film and the barrier layer, the adhesion layer being for improving an adhesion between the insulation film and the barrier layer.

14. (Amended) A method for forming a metal interconnection buried in an insulation film, comprising the steps of:

forming a barrier layer on the insulation film;

forming an adhesion layer containing zirconium directly on the barrier layer; and

forming an interconnection material containing copper as a main component on the adhesion layer.

15. (Amended) A method for forming a metal interconnection buried in an insulation film, comprising the steps of:

forming an adhesion layer containing zirconium on the insulation film;

forming a barrier layer directly on the adhesion layer; and

forming an interconnection material containing copper as a main component on the barrier layer.

17. (Amended) A method for fabricating a semiconductor device comprising the steps of:

forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

selectively removing the insulation film to form an opening in the insulation film;

forming a barrier layer on the insulation film and a region where the opening is formed;

forming a first adhesion layer containing zirconium directly on the barrier layer;

forming an interconnection material containing copper as a main component on the first adhesion layer so as to fill the opening; and

removing the interconnection material, the first adhesion layer and the barrier layer by polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, the first adhesion layer and the barrier layer buried in the opening.

22. (Amended) A method for fabricating a semiconductor device comprising the steps of:

forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

selectively removing the insulation film to form an opening in the insulation film;

forming an adhesion layer containing zirconium on the insulation film and a region where the opening is formed;

forming a barrier layer directly on the adhesion layer;

forming an interconnection material containing copper as a main component on the barrier layer so as to fill the opening; and

removing the interconnection material, the barrier layer and the adhesion layer by polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, barrier layer and the adhesion layer buried in the opening.